

APPENDIX

DETAILS OF CLAIM AND/OR SPECIFICATION REVISIONS

In the Specification:

[0001] (Amended) This invention pertains to reverse osmosis or nanofiltration membranes used for desalination of water or removal of other solutes from liquids. There is an ever-increasing need for membranes which can perform removal of solutes at lower operating pressures, thus reducing energy requirements. The goal of development efforts is to increase the water permeability of such membranes while limiting the amount of salt or other solute passage. U.S. Patents Nos. 4,765,897 and 4,812,270 describe the use of strong mineral acids followed by treatment of rejection-enhancing agents to produce low pressure water softening membranes. However, these membranes[,] are limited to 95 percent or less rejection of magnesium sulfate and even lower rejection of sodium chloride. A further disadvantage of the prior art processes is the requirement for an additional polymeric treatment step to repair the damage to the salt rejecting layer of the membrane caused by the strong mineral acid treatment step.

[0003] (Amended) The subjects of the present invention are [Improved] improved low pressure reverse osmosis and nanofiltration membranes and the process for their preparation. These membranes are produced by treating existing reverse osmosis membranes to significantly and uniquely enhance their properties. More specifically, such enhancement is obtained by contacting the salt rejecting layer of a crosslinked polyamide reverse osmosis membrane with an organic sulfonic acid compound, followed by optional drying at moderate temperature for a duration adequate to yield a membrane with a flux of at least about 15 gfd and sodium chloride rejection of at least about 20 percent when tested on 0.05 weight percent sodium chloride at 75 psi and 25°C. This membrane requires no additional treatment involving rejection enhancing agents and can typically

reject over 95 percent magnesium sulfate as a 0.2 weight percent aqueous concentration under the same test pressure. (As used herein, an "organic sulfonic acid compound" is one which is formed directly as an organic acid or which has been formed indirectly from an organic acid salt.)

[0011] (Amended) Examples of sulfonic acid compounds include simple alkyl and aromatic sulfonic and disulfonic acids. These compounds may contain other functional groups such as carboxylic acid, hydroxy, alkoxy and halo groups as long as they do not prevent the desired solvency behavior. Specific examples include but are not limited to sulfoacetic acid, sulfobenzoic acids, [sulfoisophthalic] sulfoisophthalic acids, sulfophthalic acids, sulfosalicylic acids, sulfosuccinic acid, hydroxybenzene sulfonic acids, hydroxybutane sulfonic acids and dihydroxybenzene sulfonic and disulfonic acids. The sulfonic acid is preferably a low molecular weight alkyl or fluoroalkyl sulfonic acid or mixtures thereof. Methanesulfonic acid particularly is preferred with concentrations ranging from about 5 to 100 volume percent demonstrating useful results.

In the Claims:

- [16.] 15. (Amended) A composite membrane useful for reverse osmosis or
2 nanofiltration comprising:
a supportive porous under-structure; and
4 a top layer consisting of a crosslinked polyamide thin film which is adhered
to the upper surface of the porous support structure, said top layer having been
6 contacted with a solution of an organic sulfonic acid compound,
whereby said membrane has a water flux of at least about 15 gfd and a
8 rejection of at least 20 percent when tested on a 0.05 percent aqueous sodium
chloride at 75 psi and 25°C.

[17.] 16. (Amended) A composite membrane as in Claim [16] 15 wherein said
2 crosslinked polyamide comprises the reaction product of an aromatic diamine or
triamine and an aromatic triacyl halide.

[18.] 17. (Amended) A composite membrane as in Claim [17] 16 wherein said
2 crosslinked polyamide comprises the reaction product of an aromatic diamine or
triamine, an aromatic triacyl halide and an aromatic diacyl halide.

[19.] 18. (Amended) A composite membrane as in Claim [16] 15 wherein the
2 porous support is a polyarylethersulfone.

[20.] 19. (Amended) A composite membrane as in Claim [16] 15 wherein said
2 first membrane comprises a thin film, flat sheet, hollow fiber or tubular membrane.

[21.] 20. (Amended) A composite membrane as in Claim [16] 15 wherein the
2 membrane is a component of a spiral-wound membrane filter or a plate and frame
filter.

[22.] 21. (Amended) A composite membrane as in Claim [16] 15 wherein said
2 organic sulfonic acid compound comprises a sulfoacetic, sulfobenzoic,
sulfoisophthalic, sulfophthalic, sulfosalicylic, sulfosuccinic, hydroxybenzene sulfonic,
4 hydroxybutane sulfonic, dihydroxy benzene sulfonic or dihydroxy benzene disulfonic
or a mixture thereof.

[23.] 22. (Amended) A composite membrane as in Claim [16] 15 wherein said
2 organic sulfonic acid compound comprises a C₁-C₆ alkyl, alkenyl, haloalkyl,
haloalkenyl or aryl sulfonic acid compound.

[24.]23. (Amended) A composite membrane as in Claim [23]22 wherein said
2 organic sulfonic acid compound comprises methanesulfonic acid,
trifluoromethanesulfonic acid or a mixture thereof.

[25.]24. (Amended) A composite membrane as in Claim [22]21 wherein said
2 organic sulfonic acid compound further contains a C₁-C₈ carboxylic acid, hydroxy,
alkoxy or halo functional group or a combination thereof.

[26.]25. (Amended) A composite membrane as in Claim [16]15 wherein said
2 solution of an organic sulfonic acid compound comprises said organic sulfonic acid
compound dispersed or dissolved in water, alcohol, glycol, alkoxy alcohol or a
4 carboxylic acid or a mixture thereof.

[27.]26. (Amended) A composite membrane as in Claim [16]15 wherein said
2 low pressure membrane has a sodium chloride rejection of at least about 80 percent
and a flux of at least about 5 gfd when tested on 0.05 percent aqueous sodium
4 chloride at 150 psi and 25°C.